COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

February, 1947

Photo by H. R. Toure

Recent stoker installation in large heating plant

COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

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FOR FEBRUARY 1947

FEATURE ARTICLES

EDITORIALS

DEPARTMENTS

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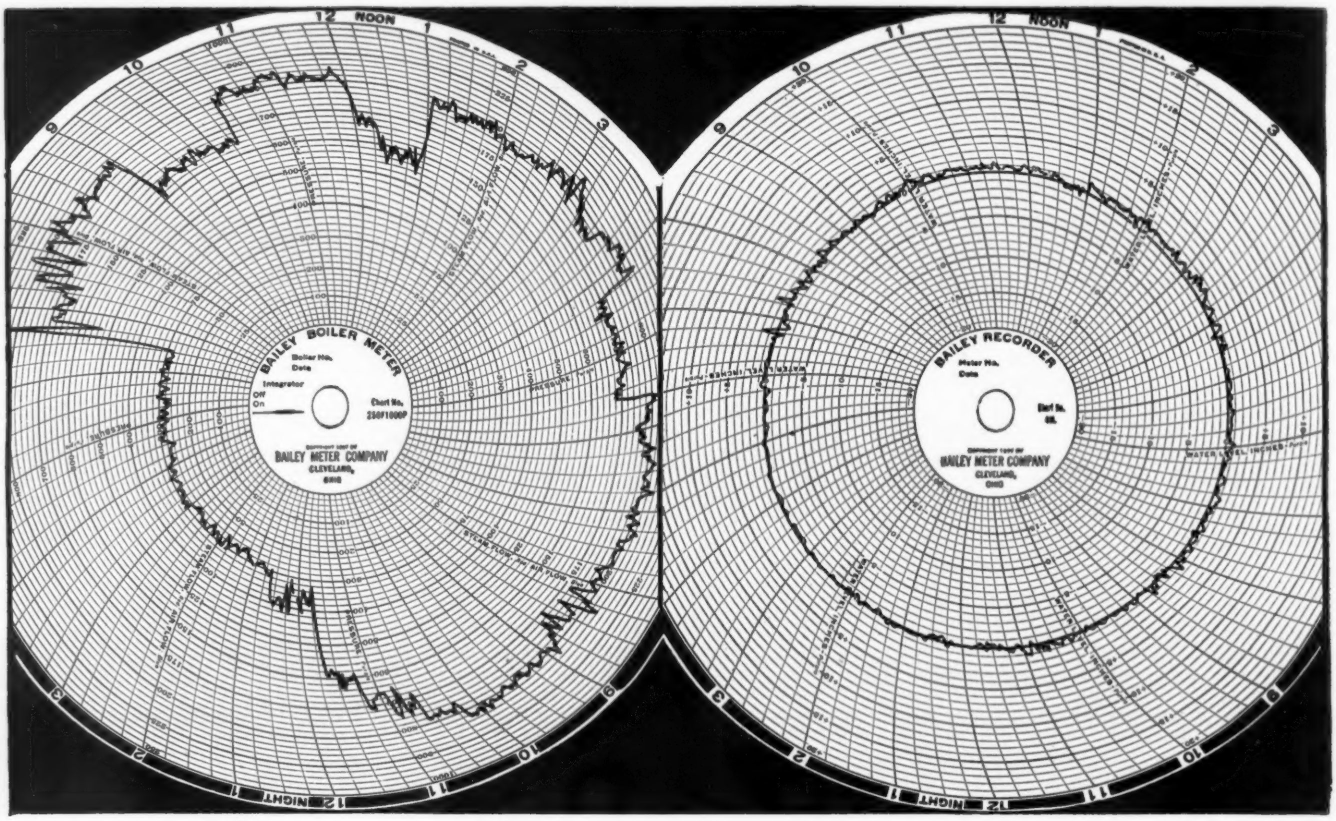

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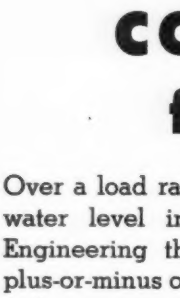

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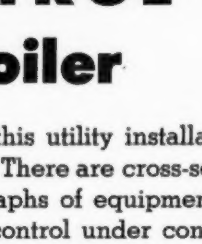

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EDITORIAL

New York City Tackles the Soot Problem

Although New York has never been regarded as a particularly smoky city, its atmospheric pollution seems to be on the increase—so much so that Mayor O'Dwyer early this month called a meeting of various groups to form a citizens' committee for pressing the movement toward cleaner atmospheric conditions. The groups participating represented municipal agencies, civic organizations, medical societies and industry, as well as harbor shipping.

It will be recalled that an extensive survey of the entire city was made by WPA during 1936–37 at which time measurements were taken at ninety-nine sampling stations throughout all seasons. However, by the time the report was completed and before definite action on it could be taken, the clouds of war began to gather, with the accompanying fuel supply problems and increased production activity, all of which precluded measures to combat the smoke problem.

This survey revealed conditions in Manhattan to be worse than those of any of the other boroughs, with an average yearly deposit of 108 tons per square mile. For the winter months this figure stepped up to 154 tons for that borough and 248 tons for the lower East Side. This section of the city not only has a high concentration of population and power plants, but since the prevailing winds are from the West, it receives considerable soot from other sections.

The Health Department, under which falls enforcement of smoke regulations, has been maintaining some fifteen sampling stations with a small force of six inspectors. It claims that soot fall has increased about forty per cent in the past ten years. Therefore, the Health Commissioner is requesting funds to increase the staff to thirty inspectors with the idea of translating the surveys into action by carrying out an educational and enforcement program in which engineers will participate and which will establish certain equipment standards.

Pre-war consumption of anthracite and bituminous coal, on a tonnage basis, was nearly equally divided in Manhattan although the former predominated in the city as a whole. The anthracite was hand-fired in over 90 per cent of the buildings and the bituminous coal was burned mechanically in the larger power plants of all types and some heating plants. A considerable number of buildings, large and small, burn fuel oil which must share with bituminous coal the responsibility for soot deposits. Also, incinerators are not to be overlooked as contributors to the nuisance.

Mayor O'Dwyer and his Health Commissioner are to be commended for focusing attention at this time on the increasing air pollution problem. It is so easy for such conditions to become worse unless constant vigilance is maintained. With the experience of many other cities to draw upon the problem should not be difficult. However, there are many contributing factors, as was so ably brought out last December by H. F. Hebley in his paper before the A.S.M.E.

Nationalization of Electrical Supply in Britain

As this issue is about to go to press the British House of Commons has approved, by a second reading, the placing of electric energy production and distribution for public use under government ownership.

Opposition to this move, as reported in the British technical press, stressed the cost of compensating the present owners and the added administrative expense of the top organization provided in the bill—factors that make it difficult to justify the promises of cheaper electricity. The opposition also contended that, although compensation is to be at current market quotations for the utility stocks, the government bonds that are to be given in payment will yield a much lower rate of return.

This latest step, following closely upon nationalization of the coal industry, is in line with the platform of the party now in power, and as such has political rather than economic significance.

In both industries the present situation is reported as bad, even aside from the critical situation precipitated early this month by the unusually severe weather and inadequate coal stocks. For some time Britain has been on short coal rations which have seriously interfered with much needed expansion of industrial production. This has been attributed to shortage of manpower, depletion of the best mines, and failure to replace obsolete mining equipment. As elsewhere, coal costs have risen and quality deteriorated. Inadequate electricity supply was also being felt keenly in both the industrial and the residential fields, this shortage being attributed to insufficient generating capacity as well as to the existing fuel situation.

To what extent, if any, nationalization of these two industries will be able to correct former shortcomings remains to be seen. The outcome will be watched closely from this side of the Atlantic where outstanding expansion in the supply of electric energy has been achieved, at progressively decreased rates, under private initiative which so splendidly met the vast demands of the war.

Fuıther Topping at SHERMAN CREEK
Part II — Turbine and Auxiliaries

By H. KNECHT
Asst. Mech. Plant Engineer,
Consolidated Edison Co. of New York

Part I, under the authorship of R. T. Roberts, which appeared in the January issue, dealt with the steam-generating equipment of this installation. The present article carries on from there covering the turbine-generator, the various auxiliaries, piping, controls and flow diagram.

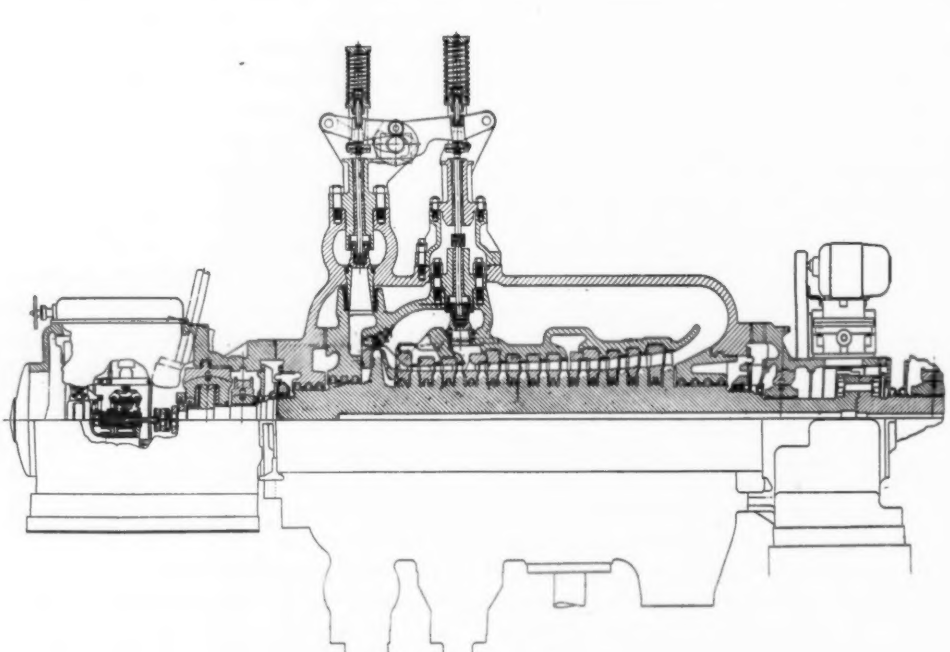
As PREVIOUSLY noted, to continue the plan laid out at the time of the first topping installation in 1943, the Consolidated Edison Company has now under way the installation of a second high-pressure boiler and turbine-generator at Sherman Creek Station, where successful operating experience with the first unit has dictated duplication of the general layout.

The million-pound-per-hour boiler feeds steam at 1600 psi, 950 F to the turbine through a single $17^1/_2$-in. O.D. lead, omitting the conventional and costly motor-operated gate valve. The main steam piping has been so laid out that an anchor at the turbine causes vertical expansion of the riser to the superheater. The expansion is taken up in the long horizontal flexible superheater tubes that tie into the spring-supported superheater header.

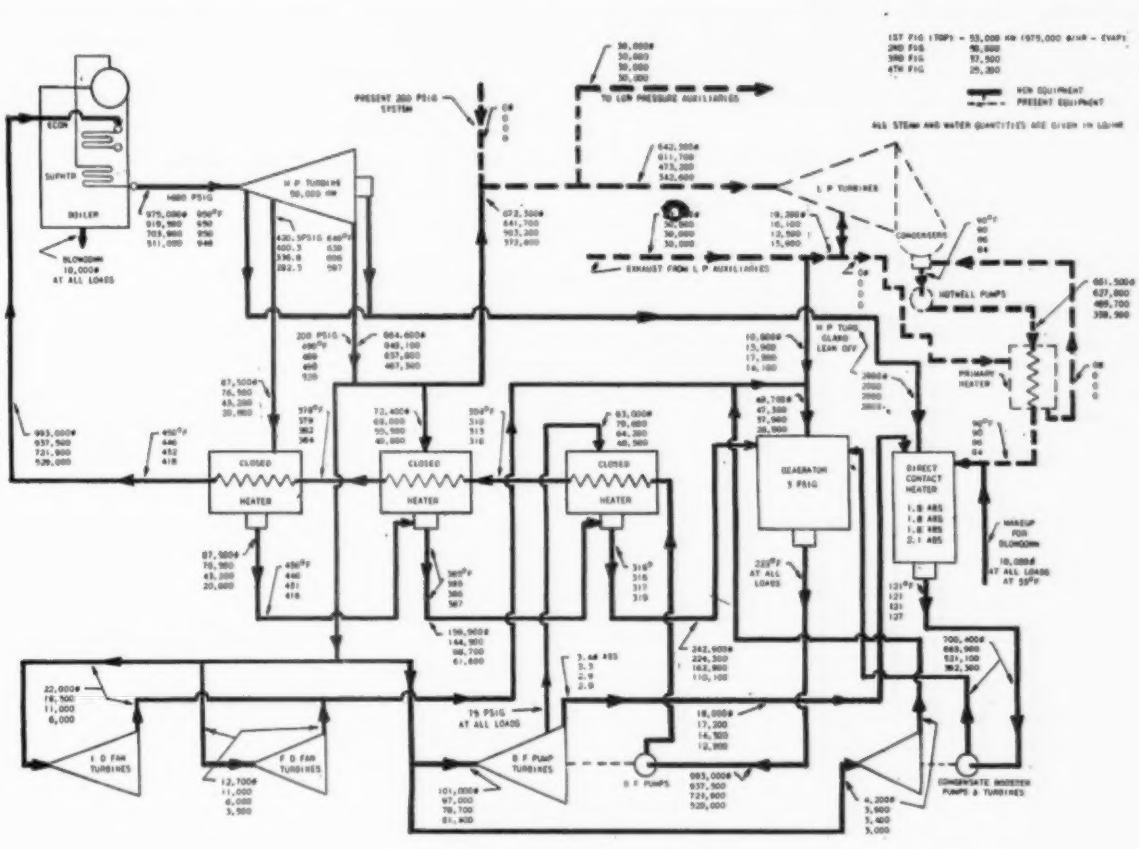
Feedwater to the boiler is controlled by a three-element system in which the requirements of steam flow, water flow, and drum level are combined and satisfied by varying the speed of the turbine-driven boiler-feed pumps.

It is planned to use the same starting procedure on this unit that has been successfully used on the first machine. The boiler and turbine are essentially brought up together, turbine and piping drains being held open until the boiler pressure reaches 400 psi. At that time the turbine exhaust valve is opened and from this point on, all of the steam passes through the machine and into the station's 200-psi system. Gland leak-off steam is carried to the subatmospheric direct-contact heaters.

Absence of vibration difficulties with the present unit guided the selection again of a short foundation of concrete.



Section through high-pressure turbine



Flow diagram for four loads

All of the piping has again been laid out in a simple single-line system, eliminating costly by-passes, extra valves and cross-connections. The choice of this type of system has been justified by operating experience. Using practice carried on during the war, the turbine manufacturer is planning to ship the turbine and generator, each almost completely assembled. This will minimize the amount of field erection.

Main Turbine

The turbine-generator, manufactured by the General Electric Company, is rated at 50,000 kw at 0.8 power factor, 13,800 volts, 60 cycles, 3-phase, and operates at 3600 rpm. Design steam conditions are 1600 psi, 950 F at the throttle, 400 psi at the bleed point and 200 psi, 485 F at the exhaust.

As indicated in the cross-section, this turbine is a single-flow double-shell machine having 14 impulse stages. The inner shells are not rigidly attached to the outer shells, and are provided with supports and guides to permit radial expansion. The outer shells are supported by arms resting on the front and middle bearing standard. The middle standard is bolted and keyed to the foundation sole-plate, and the unit expands forward toward the governor end. The turbine end standard carries the thrust bearing and is provided with a guide key and gibs so that it moves freely on the base underneath it. The thrust, being moved with it, maintains the relative clearances between rotor and stationary parts throughout.

This turbine is equipped with ten control valves arranged in two groups of five each and mounted on the upper and lower control valve casings which are integral with the top and bottom outer turbine shells. Of these ten valves, six admit steam to different sections of the first-stage nozzle, and four by-pass overload steam to the fourth-stage shell. All valves are under control of the operator governing mechanism which is of the centrifugal type driven by the turbine shaft through a worm gear. A quick-closing oil-operated stop valve is provided for the steam inlet to the high-pressure end. This stop valve is tripped closed either by hand or by the emergency governor in the event of overspeed. Steam from the stop valve is admitted to the upper and lower control-valve chests by two pipes designed for suitable flexibility.

Oiling System

Two main gear-type motor-driven oil pumps will be located in the main oil tank to be installed in the basement. All the oil delivered by these pumps will pass through oil coolers located inside of the oil tank. An auxiliary steam turbine-driven oil pump is also provided in the main oil tank to supply oil during starting and stopping of the main unit. By means of a pressure regulator this pump automatically comes into operation when the oil system pressure drops below a pre-determined point.

In addition, a small motor-driven oil pump has been provided to supply oil to the bearings when the unit is

on the motor-driven turning gear.

For supervisory control the machine is equipped with a vibration recorder, an expansion indicator, a shell and differential expansion recorder, an eccentricity recorder, a speed and camshaft position recorder and a back-pressure regulator.

Electric Generator

The generator is hydrogen cooled and rated at 50,000 kw 0.8 power factor, 62,500 kva, 3600 rpm, and 13,800 volts. With rated voltage and power factor and at 15 lb hydrogen pressure it will have a maximum kva output of 115 per cent rated kva.

Four extended-surface type hydrogen cooler sections are provided and located vertically, one at each corner of the generator stator outside the core portion. Water connections will be at the bottom and all water gaskets will be externally located to prevent leakage into the hydrogen space. The cooling is accomplished by fresh water to be recirculated and, in turn, cooled in a heat-exchanger by using salt water. Proper equipment is supplied for vacuum treating the oil used in the shaft seals. These seals prevent leakage of hydrogen along the generator shaft.

Condensate System

Condensate from the low-pressure turbine hotwell pumps is discharged into a common header feeding both the two remaining open heaters which supply the remaining low-pressure boilers and the direct-contact heaters related to the high-pressure installation. The piping is arranged so that condensate goes first to the direct-contact heaters and the excess to the open heaters

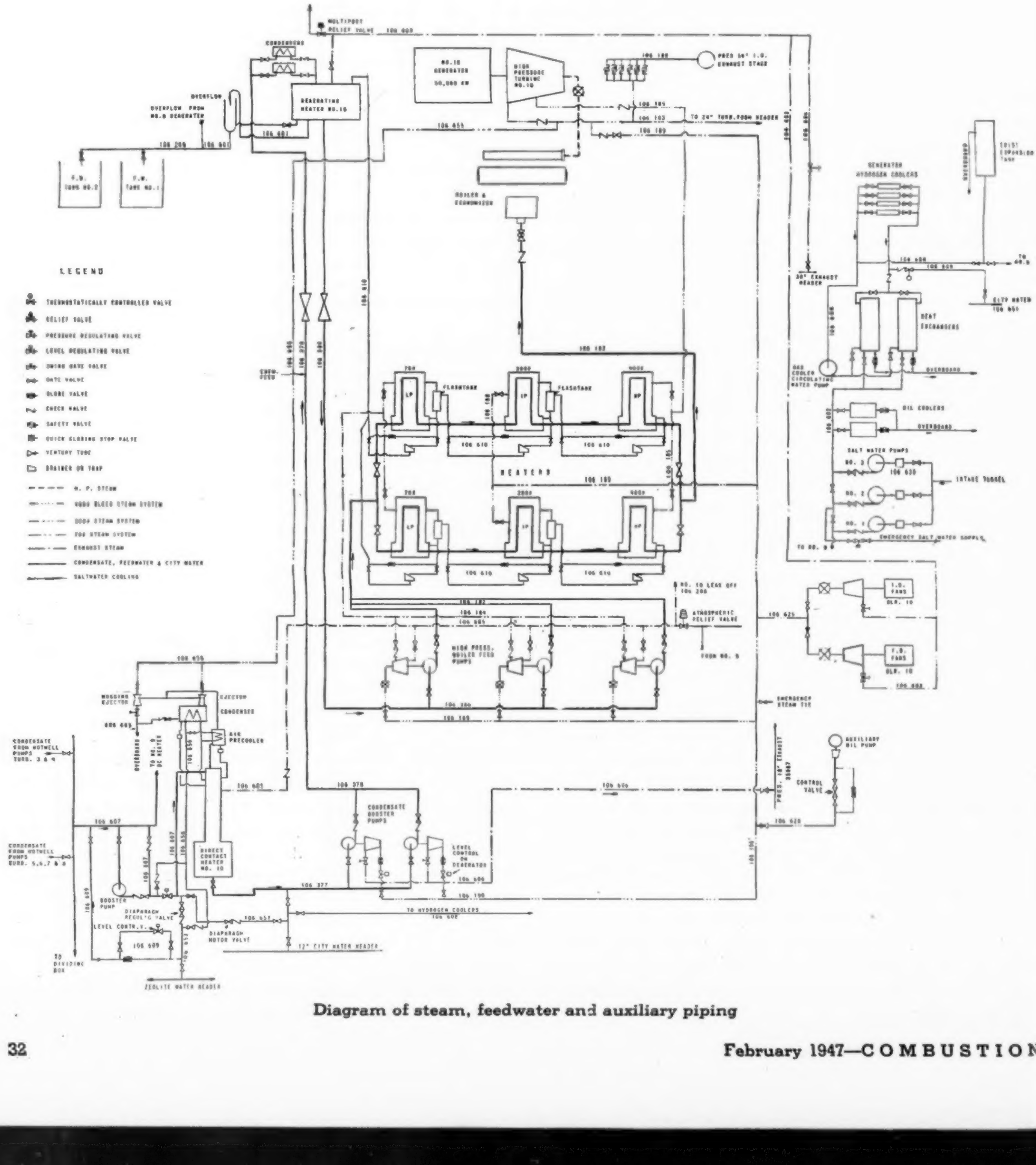


Diagram of steam, feedwater and auxiliary piping

for use in the low-pressure boilers. In the condensate header to the direct-contact heaters are installed vertical booster pumps, one for each heater, arranged to start up automatically when the direct-contact heaters go atmospheric.

The direct-contact heater installed under this project is a vertical Elliott jet-type counter-flow heater equipped with twin steam-jet air ejectors, integral direct-contact precooler, and surface-type after-condenser. This heater is designed to condense 20,000 lb of steam per hour with 642,000 lb of feedwater, to 3 psi absolute with an effluent temperature of 140.5 F.

Two Westinghouse turbine-driven DeLaval condensate booster pumps, one a spare, take the water from this heater and pump it to the deaerating heater. The deaerator is an Elliott direct-contact tray-type equipped with two vent condensers so valved as to permit isolation of either one for overhauling, without taking the heater out of service. Heating steam at approximately 3 psi gage is supplied from the exhaust of the forced- and induced-draft fan turbines nearby and from the low-pressure station auxiliaries. High-pressure closed feedwater heater condensate returns are flashed into the shell above the water level.

Feedwater at approximately 222 F flows from the deaerator to the suction of the high-pressure boiler feed pumps. The elevation of the deaerator is such as to maintain a positive suction head in excess of 40 psi gage at the pump center line. As in the previous installation, there are three turbine-driven variable-speed boiler feed pumps; two of these are for full load operation and one a spare. They are Byron Jackson eight-stage pumps incorporating the outer barrel and horizontally split inner case design. The normal full load capacity of each pump is 460,000 lb per hour against a total dynamic head of 1800 psi gage, at 4150 rpm.

These pumps are each directly driven by a General Electric condensing, controlled extraction-type turbine. Each has a normal rating of 1357 hp at 4150 rpm with 185-psi, 485-F steam to the throttle. Steam is extracted at 90 psi absolute for feedwater heating and the turbine exhausts to a direct-contact heater at 3 psi absolute. The turbine will develop a maximum of 1685 hp at 4340 rpm under the same steam conditions. This capacity may be required when carrying full load with only one set of heaters in operation. These units are so designed that in case of emergency any one may be put into immediate service without warming up. However, a turning gear is supplied to rotate the unit at about 13 rpm for normal warming-up periods.

There are three means provided for controlling feedwater to the boiler, namely, automatic, remote manual and local manual. The equipment is the Bailey Meter Company's three-element system, arranged to vary the speed of the boiler-feed-pump turbines so as to maintain a balance of water flow against steam flow, compensated by drum level variation.

From the common boiler-feed-pump discharge header, the water is pumped through two parallel rows of closed heaters. Each row consists of one low-pressure heater using steam at 85 psi gage from the boiler-feed-pump turbine extraction; one intermediate-pressure heater using steam at 195 psi gage from the high-pressure turbine exhaust and one high-pressure heater using steam at 390 psi gage from the high-pressure turbine extraction point. Under normal conditions the total flow of feedwater is handled through both sets of heaters. However, the piping and valves are so arranged that in case an outage is necessary, one row may be isolated by gate valves set ahead of the low-pressure and beyond the high-pressure heaters. Full flow is then passed through one set of heaters, resulting in an increased pressure drop, but maintaining reasonable efficiency. The feedwater heaters are the Foster Wheeler vertical U-tube, 2-pass lockhead type, utilizing cupro-nickel tubes.

Experience with the first high pressure installation indicates that the same degree of efficiency and successful operation may be expected when this installation goes into operation.

LIST OF EQUIPMENT

Turbine

(1) *General Electric Co.* 50,000-kw at 0.8 p.f., 3600-rpm, single-flow, double-shell, 14-stage impulse type. Normal steam at the throttle is 1600 psi and 950 F, exhausting at 200 psi and 485 F.

Generator

(1) 50,000-kw, 0.8 p.f., 62,500-kva, 3-phase 60-cycle, 13,800-v, 3600-rpm hydrogen-cooled unit with air-cooled direct-driven exciter.

Direct-Contact Heater

(1) *Elliott* vertical jet type counter-flow heater with twin steam jet air ejectors. Rated capacity designed to condense 20,000 lb per hr of steam with 642,000 lb per hr of feedwater to 3 psi absolute with effluent temperature of 140.5 F.

Deaerating Heater

(1) *Elliott* direct-contact tray-type with 2 vent condensers. Rated capacity 1,100,000 lb per hr, 18 psi absolute with 1000 cu ft water storage, dissolved oxygen content not to exceed 0.005 cc per liter (*Schwartz-Gurney*).

Closed Feedwater Heaters

2 sets of 3 *Foster Wheeler* vertical, 2-pass, U-tube Lockhead type heaters with integral hotwells. Each set consists of one 2090 sq ft of effective surface, 70-psi gage heater; one 1910 sq ft of effective surface, 195-psi gage heater and one 2650 sq ft of effective surface, 390-psi gage heater. The tubes are 80–20 cupro-nickel.

Condensate Booster Pumps

2 *De Laval* single-stage, double-suction type 275 TDH, 20-ft suction lift, each pump driven by a *Westinghouse* turbine at 1875 rpm.

Boiler Feed Pumps

3 *Byron Jackson Co.* horizontal, 8-stage double-case volute type. Normal full load 460,000 lb per hr, 1800 psi gage 222F, 4150 rpm. Direct-connected to a *General Electric* 1685-hp variable-speed condensing automatic extraction mechanical-drive turbine with automatic turning device. Steam 200 psi absolute, 485 F and 4 psi absolute back pressure.

Salt-Water Cooling Pumps

2 *Warren* single-stage double-suction type, each with a capacity of 2000 gpm against 100 ft total net head including 22 ft suction lift. Direct-connected to a 75-hp *Westinghouse* 1800-rpm motor.

Hydrogen-Cooling Water Pump

1 *De Laval* single-stage centrifugal pump; 400 gpm against 75 ft. Driven by a 15-hp 1800-rpm *General Electric* motor.

Gland-Cooling Pump

1 *Ingersoll-Rand* single-stage centrifugal pump. 50 gpm against a TDH of 125 ft. Driven by a 5-hp 3450-rpm *Westinghouse* motor.

Prospects of the Steam Cycle in the Central Power Station*

By G. H. MARTIN†

Despite advances in the gas turbine, the author believes the steam turbine will hold the field for large power generation for many years to come. Data are given indicating the gain in thermal efficiency for increased steam conditions up to 2000 psi and 1000 F with and without reheating. Advantages of reheating to obtain higher efficiency are emphasized.

At THE British Association meeting held at York in 1881 a gas engine was exhibited which very much impressed Sir Frederick Bramwell and prompted him to make a prophecy to the effect that in 50 years from that date steam machinery would be found only in museums, its place having been taken by the gas engine. He was so confident in this conviction that he left a sum of money to be awarded to a lecturer who would review the progress of the prime mover in 1931, doubtless expecting this lecture to justify his prophecy. Subsequent development has, however, proved his forecast to be entirely inaccurate.

A somewhat similar situation exists today with regard to the gas turbine which under impetus created by wartime requirements has developed with such rapidity that many engineers are questioning whether it may not soon displace the steam turbine as a prime mover. The author of the present paper regards these views as too optimistic and is tempted to prophesy that the steam turbine will hold the field for large power generation for many years to come, there being no immediate prospect of any other form of prime mover or alternative source of energy becoming a serious competitor for the generation of electricity in the central power station.

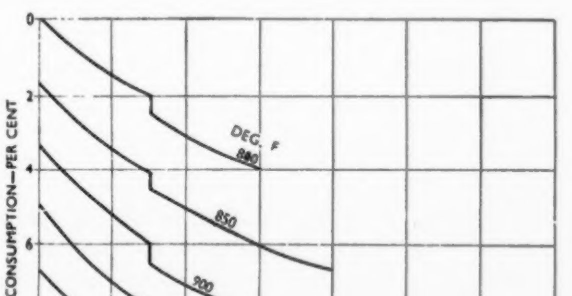


Fig. 1—Reduction in overall heat consumption with increasing steam pressure and temperature

Thermodynamic Considerations

In the 25 years prior to the Second World War the steam conditions in the central power stations in Great Britain increased from 250 psi and 600 F to 600 psi and 800 F. Except for isolated examples in the extra high-pressure range, these latter conditions had become standard for the stations of the Central Electricity Board immediately before the war. Higher conditions would have involved an additional capital outlay, the returns from which were not considered sufficiently attractive, with coal then at a low price, to justify the increase in capital expenditure. Today the whole basis of the economics of power station design has been changed by the very considerable and unexpected advance in the cost of fuel over the last few years. Consequently, schemes that were not considered economic with coal at pre-war prices now show very attractive returns.

This paper refers primarily to the large central station, the generating unit being of the order of 50,000 kw.

Mr. Baumann in his recent paper[1] fully investigated the non-reheat cycle; but as the present paper includes investigations into the reheat cycle, the simple cycle has been recalculated on the same basis, so as to ensure that the curves are mutually consistent. Callendar's 1939 Steam Tables have been used throughout.

Curves showing the reduction in heat consumption with increasing steam pressure and temperature are shown in Fig. 1 for a non-reheat cycle and in Fig. 2 for a single-stage reheat cycle. Both series of curves show the advantage over steam conditions of 600 psi pressure and 800 F, with a constant vacuum of 28.5 in. and a cooling water temperature of 70 F. The final feed temperature in all cases has been taken as 70 per cent of saturation corresponding to the initial steam pressure. The number of feed heating stages is indicated and the disposition of the heaters is the best within practical limitations.

Changes in internal efficiency in the wet region have been based on the usual 1 per cent stage for each 1 per cent of water present in the steam. The temperature at

* From a paper before the Northeastern Branch of The Institution of Mechanical Engineers on October 7, 1946 at Newcastle-upon-Tyne.
† With C. A. Parsons & Co., Ltd.

1 Baumann, K., 1945 I. Mech. E. *Proceedings*, "Improvements in Thermal Efficiencies with High Steam Pressures and Temperatures in Non-reheating Plant"; abstracted in COMBUSTION November 1945.

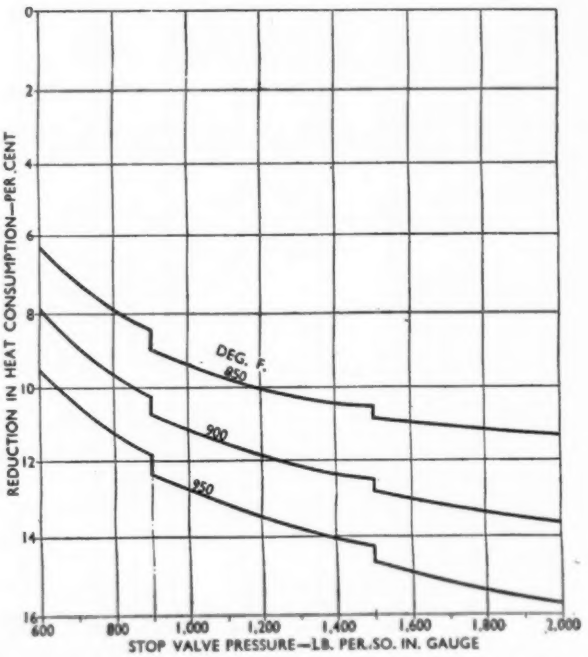


Fig. 2—Reduction in overall heat consumption with increasing steam pressure and temperature when employing one stage of reheating

the boiler feed pump suction is taken as 210 F, and in all cases there are two low-pressure heaters.

In Fig. 2, the pressure at which reheating takes place is 27 per cent of the initial pressure. This pressure has been maintained as high as is reasonably possible to keep down the size of piping to and from the reheater. The pressure drop has been taken as 10 per cent of the pressure at which reheating takes place.

The power consumed by the feed pumps and condenser auxiliaries is included. Fig. 3 shows the pressure at the feed pump discharge with various steam pressures at the turbine stop valve from which the power consumed by the feed pump has been calculated. The condenser extraction pump has been assumed to have a discharge head of 120 ft and the circulating water pump an external head of 30 ft.

The gain due to reheating, as obtained from the difference between these two curves, is shown in Fig. 4. It may seem surprising that the gain declines with increase in steam pressure. This can be partly explained by the fact that a greater proportion of steam is extracted for feed heating as the initial pressure rises; consequently, a smaller proportion of work is done in the wet region. Although the decline is only of the order of one-half of 1 per cent, and is not noticeable in the main curves, it is a considerable proportion of the reheating gain when this, at best, is only 4.75 per cent.

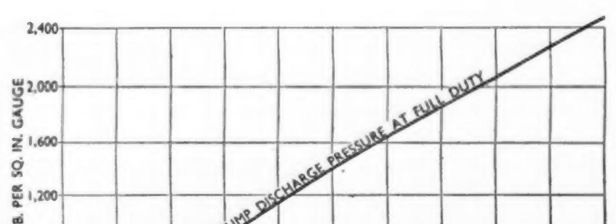


Fig. 3—Pressures at feed pump discharge with various steam pressures at the turbine stop valve

There is no general limitation to the permissible wetness at the turbine exhaust, because its effect is closely allied with vacuum and the rotational speed of the blading concerned. In the case of a 50,000-kw set the rotational speed would not justify exceeding 12 to 13 per cent measured at the exhaust after the velocity has been destroyed. The early troubles due to erosion of the blading caused by wetness have now been overcome by blade protection and cylinder drainage, and therefore no longer present a problem.

A number of improvements can be effected without capital outlay. The feed system is a fruitful field for investigation. Fig. 6 shows the essential framework of a five-stage feed heating system. It is common practice to install the unit evaporator between the H.P. 3 and H.P. 2 extraction points (Fig. 6), all drains being "cascaded" through the system to the condenser. If the evaporator is placed at the low-temperature end of the system, as

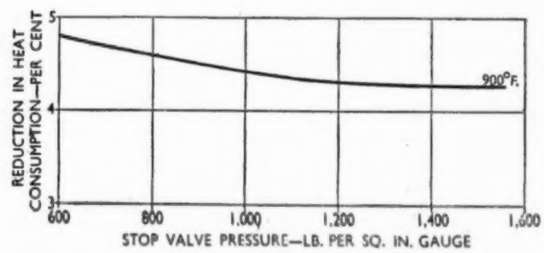


Fig. 4—Effect of initial steam pressure on the reduction in heat consumption due to one stage of reheat

indicated by scheme 2, Fig. 6, there is a saving of 0.38 per cent. If a second drain cooler is added (scheme 3) a further 0.1 per cent is obtained. If, instead of a second drain cooler, a drain pump is added in the position indicated in scheme 4, a further 0.33 per cent can be saved, making:

	Per cent
Low-pressure evaporator and second drain cooler	0.48
Low-pressure evaporator and drain pump	0.71

While not condemning drain pumps, it must be pointed out that their duty is particularly arduous, owing to the wide variation of pressure and condensate flow to which they are subjected. Care should be taken, therefore, to see that sufficient gain is actually obtained to justify the use of such pumps.

No attempt has been made to develop empirical formulas for estimating the economic conditions. Such calculations are dependent upon a knowledge of the increase in price, not only for the generating unit but for the boiler also. Neither can be predicted with certainty, consequently little value could be attached to the results of calculations based on assumed costs, although from an academic point of view they may be interesting and probably useful as a rough guide. The final selec-

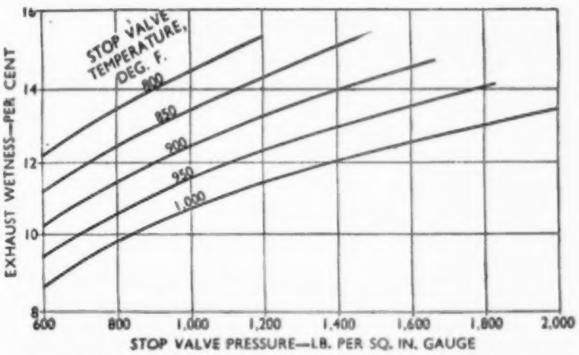


Fig. 5—Curves showing exhaust wetness under various conditions with no reheat. The wetness under reheating conditions never exceeds 5 per cent

tion of conditions must be dependent upon the actual costs and details of the layout.

With the curves and data here set out it is still impossible to draw any final conclusion or to give any definite recommendation as to the most economic steam conditions for any particular project. One can do no more than use the curves for estimating probable gains in heat consumption with increased steam conditions and consider the technical merits of various cycles.

The table shows what (it is suggested) may be regarded as a reasonable range of steam conditions from which to make a choice for large central stations. Taking 600 psi pressure and 800 F total temperature as a datum, the estimated fuel saving to be expected with other steam conditions is shown.

ESTIMATED FUEL SAVINGS

	Stop Valve Pressure, Psi	Stop Valve Temperature, F	Reheat, F	Saving, Per Cent
a	600	800	..	...
b	900	900	..	6.5
c	1200	950	..	9.6
d	900	900	900	10.75
e	1200	900	900	11.8
	1500	950	950	14.6

It is evident that steam conditions are now approaching a point where the law of diminishing returns is beginning to make itself felt, and the conditions or unit size now selected are likely to remain economically justifiable very much longer than in the past. This emphasizes the importance of choosing a cycle which will give the maximum fuel economy without resorting to conditions likely to cause increased difficulties in operation and maintenance.

It is suggested from the operating point of view there is much to be said against resorting to pressures and temperatures so high as have been advocated recently by some engineers. In support of this view, it will be seen from the table that a remarkably good fuel economy can be obtained with comparatively moderate pressures and temperatures, if reheating is employed. Cycle *d*, for example, shows an economy of nearly 11 per cent without exceeding a pressure of 900 psi or a temperature of 900 F.

Reheating has not always been popular because it is assumed that its introduction considerably complicates the operation and introduces some special problems. Certainly when reheating was first introduced many difficulties were anticipated and provision was made against them, but few were found to occur. Special starting instructions were laid down and an extended time was regarded as necessary to bring the plant on to the bars. It was generally the practice to run the plant up with the reheater isolated, and it was only brought in gradually after the machine was on the bars. Experience now indicates that plant incorporating reheating, if properly designed, should be just as flexible and take no more time for starting than one operating on a "straight" cycle. With the reheater drains arranged to discharge into the main condenser the whole plant can be brought up with the reheater in circuit, with temperature increasing as load is put on.

It may be that the boiler is the deciding factor in the selection of steam conditions with reheat. As the initial pressure is increased, the superheater zone is extended. This may make it difficult to accommodate a reheater without overlapping into the furnace zone. This consideration would suggest that the feed temperature should be increased when reheating is adopted.

The maximum possible thermal efficiency (ratio of energy in fuel to energy represented by kilowatts output) is about 34 per cent with a "straight" cycle and 36 per cent with single-stage reheating. This is far from satisfactory, and other means must in time be developed to use our fuel resources more efficiently. The most promising avenue of development is district heating, using back-pressure plants discharging steam into mains for distribution and hot water for space heating.

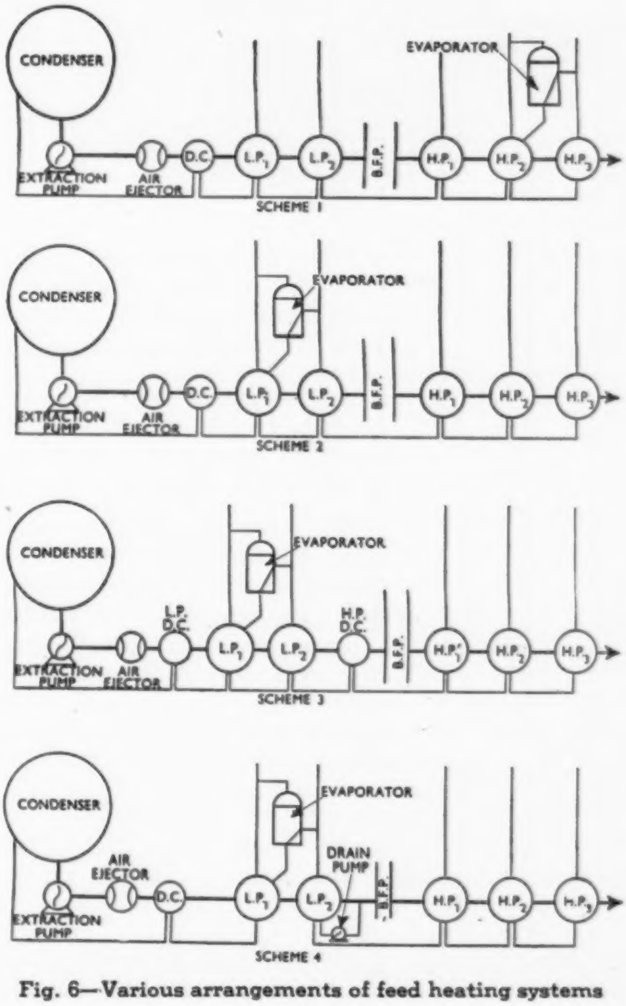


Fig. 6—Various arrangements of feed heating systems

A Theory of Carryover

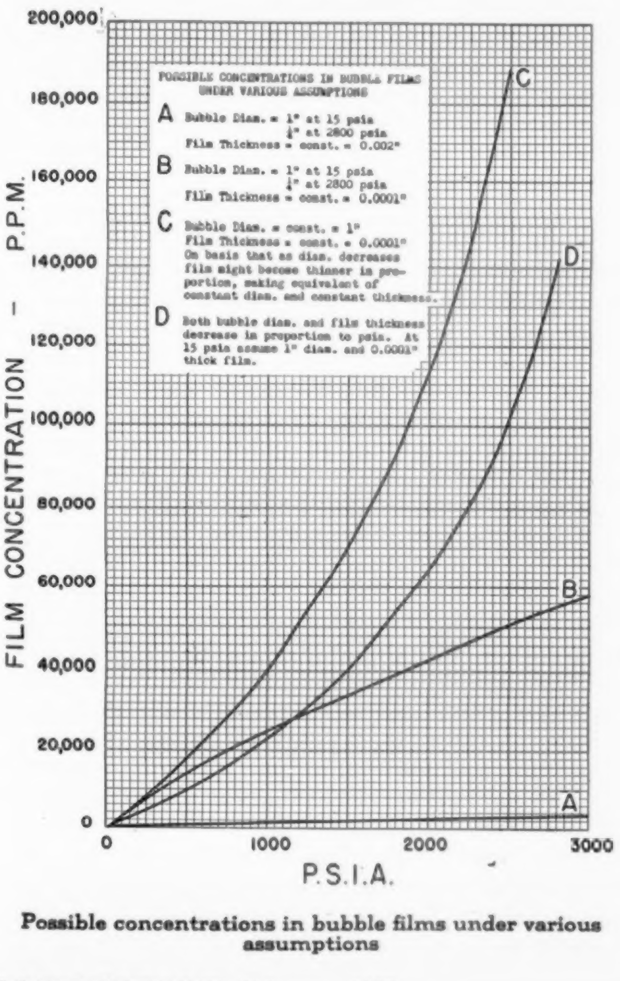
Based on the idea that chemical in water from which steam is made is concentrated in a film surrounding the steam bubble, a theory has been evolved relating operating pressure and chemical concentration to steam contamination. It is offered to account for certain heretofore unexplained phenomena.

By A. R. MUMFORD

Research and Development Dept., Combustion Engineering Company

ACCORDING to the generally accepted conception of heat transmission through a boiler tube, or other heat-transfer surface, the layer of water adjacent to the inner surface is slightly superheated. The evaporating process is accompanied by a change in volume that is greatest at low pressures and decreases as the pressure increases. The water droplet, which is vaporized into a steam bubble, contains some dissolved material that is not evaporated and consequently adds to the concentration of the unevaporated water.

If evaporation proceeds to dryness, then dry chemicals must be presumed either to deposit on the heating surfaces or to exist in the bubble of vapor where they would be redissolved in the liquid phase at the bubble boundary in a layer of higher concentration than the average for the boiler water.



Possible concentrations in bubble films under various assumptions

It is possible that sufficient superheat might exist at the inside metal surface to produce local evaporation to dryness; but in that case the resulting deposit, because of the adjacent steam film, would not be redissolved, the salts would build up, and a burn-out would most likely follow. In fact, it is difficult to conceive of any way in which such deposits could occur without causing burn-outs or without leaving evidence when the boiler has been opened for inspection. Obviously, if deposits thus occurred burn-outs would be frequent and widespread. Since this is not the case, the assumption fails.

This leads to the belief that the soluble material must remain dissolved in the liquid and most likely concentrates in the film surrounding the steam bubble, to a degree dependent upon the size of the bubble and the thickness of the film. The surface tension rises with the concentration of dissolved matter and the film strength could be high even at the high temperatures accompanying high pressures. The film would also serve as a carrier for water-treating chemicals and as such may provide an explanation of the so-called "hide-out" which is sometimes encountered, and for which several theories have been advanced.

If it be assumed that the dissolved matter in the boiler water is concentrated in a film at the interface between the liquid and vapor phases, it is apparent that the concentration in the film would increase with pressure even though the boiler water concentration remained the same. The following table indicates the effect of pressure on the volume changes involved in vaporization:

Psia	Volume 1 Lb Water Cu In.	Volume 1 Lb Steam Cu In.	Expansion Ratio
15	2.41	3863.00	1603.0
50	2.49	1228.00	493.0
100	2.55	637.60	250.0
200	2.65	328.60	124.0
500	2.84	133.80	47.1
1000	3.11	64.07	20.6
1500	3.38	39.89	11.8
2500	4.13	19.00	4.6
2800	4.54	14.98	3.3

The volume of a given weight of steam is not a measure of the surface of the interface between liquid and vapor unless the diameter of the individual bubbles is the same at all pressures. However, little actual knowledge is available on this subject of bubble diameter. The bubble diameter ought to decrease with increased pressure, because the degree of concentration and, therefore, the surface tension increases with pressure. The effect of increase in temperature on surface tension is not believed sufficient to offset materially the effect of film concentration.

Any estimate of the effect of pressure on bubble size must be an assumption at this time, so several assumptions have been made; first, that the bubble diameter

decreases through an arbitrary range with increased pressure; second, that the bubble diameter decreases inversely as the absolute pressure. In order to estimate the degree of concentration it is necessary to assume film thicknesses. It is obvious that the degree of concentration would increase inversely as the film thickness for bubbles of the same diameter.

For the computations on which curves *A*, *B* and *C* of the accompanying chart are based, constant film thicknesses of 0.002 in. and 0.0001 in. were assumed and in one case (*D*) the film thickness was assumed to change inversely as the absolute pressure. The curves show that except for constant size bubbles with a coarse film (0.002 in.) the film concentration could go up to about 25 per cent dissolved solids from a boiler water containing only 0.05 per cent solids. The increase is, of course, greatest at the higher pressures but exists at pressures of 200 or 300 psia to a significant extent. A theory has therefore been developed under which strong films would be formed around bubbles of steam and under which the film strength would increase rapidly with increase in pressure even in dilute boiler waters. It is not known how rapidly diffusion would tend to decrease the film concentration but velocities of 1.5 to 2 ft per sec have been measured at the entrance to heat absorbing tubes and velocities of several feet per second leaving such tubes are reasonable. About fifteen seconds may, therefore, be the time in which a concentrated film could lose some of its concentration by diffusion. If the film is of molecular thickness, as in the case of soap bubbles in air, rather than the 0.0001 in. as assumed, the initial concentrations would be tremendously higher and complete equalization with the boiler water by diffusion extremely unlikely.

Concentrated Films vs Chemical Reactions

It is interesting to speculate on the effect of such concentrated films on the chemical reactions involved in the prevention of the deposit of scales on heating surfaces. Phosphate concentrations of 0.003 to 0.005 per cent are commonly maintained in boiler waters. This is a very dilute solution and completion of reaction could be secured only by violent agitation. If, however, concentrations of 15 to 25 per cent in the bubble films exist then reactions would be practically instantaneous. In the tubes the concentrated bubble film would be brought into contact with metallic ions of the heavy earth group by bubble slip and turbulence and the reaction would be equivalent to the replacement of soluble components by insoluble components in the film. The bubble film, containing some insoluble matter, would now act as a carrier discharging the concentrated film into the steam space of the drum.

Whether or not the bubble film were brought into contact with scale-forming ions in the tubes, it would certainly act as a carrier for a concentrated chemical solution to the drum where reaction with the elements in the incoming feedwater would be rapid and complete. The location of deposits found in drums indicate that most of the reaction occurs where the raw water is first met by the boiler water, and this is in the drum.

On the supposition that each steam bubble is surrounded by a highly concentrated film of high surface tension and strength, it is necessary to violently agitate these bubbles with boiler water to reduce the film concentration and weaken the film to a degree that will allow it to burst and release the steam. Any spray resulting from the breaking bubbles must be mechanically trapped out of the steam.

Under this theory of carryover, the expansion ratio indicates why there is a stronger bubble film at high pressure than at low pressure. For this reason carryover may occur at high pressure from a boiler water which produces only a weak unstable film at low pressures. As the boiler water concentration increases, the bubble film concentration and strength increases and the separating and purifying equipment may become overloaded and unable to destroy the strong bubble films.

As the rate of steam generation increases, the number of bubbles delivered to the drum increases, and if the drum internals are not designed to destroy the bubble film completely some will collect on the surface of the water, floating as a mass. It is known that the bubbles will deposit the film on a screen and eventually fill the screen interstices with film, so that any additional steam will simply blow bubbles from the screen. Thus, if the floating mass of bubbles is increased in volume at a rate faster than the natural breaking rate, the mass will eventually build up to the outlets and carry over.

Similarly, the mass of bubbles floating on the water may be raised to the outlets by raising the water level and result in carryover. A mass of bubbles of a steady constant volume may exist at a given rating without causing carryover if the bubble surfaces are draining and weakening to the breaking point at a rate equal to the rate of replenishment from the risers.

The foregoing would appear to be confirmed by the following observations:

1. The American Boiler Manufacturers Association, based on experience, decreases the permissible concentration of dissolved solids in boiler water with increase in pressure. This is justified by increase in bubble film concentration resulting from the change in expansion ratio with pressure.

2. At one large central heating plant where steam is generated at 285 psig and nearly 100 per cent makeup (treated within the boiler) is employed, carryover occurred at all except very low ratings. Deposits of insoluble solids were found on turbine blading within the plant and on valves distant as much as a mile. Concentrations of 1500 ppm of dissolved materials were carried in the boiler along with about 1500 ppm of suspended matter. The carryover was essentially uncontrollable until perforated plates were placed in the drums at and covering the water level. Subway gratings have accomplished the same purpose in other instances. These plates effectively broke the bubble films at the releasing surface and thereby stopped carryover. It is possible that the same plates might not have been as effective at higher pressures because of stronger bubble films.

3. Samples of wet steam leaving the front drum of a three-drum boiler contained approximately 90 per cent as high concentration of dissolved material as did the boiler water. This would indicate concentrated bubble films, for apparently nearly the same quantity of dissolved material was carried by the bubble films as existed in the water from which the steam was generated. The strength of the films can be inferred from the fact that they carried through several reversals of flow caused by baffling.

4. In a test boiler drum, supplied with steam from another boiler it was necessary to employ concentrations of 8000 ppm and more of dissolved material to produce strongly foaming conditions at atmospheric pressure; and when the foam bubbles broke on the surfaces of the internals a powdery deposit was left with little appearance of wetting. This would seem to bear out the theory that the film concentrating action would be a minimum at atmospheric pressure, thus requiring high boiler water concentrations under such pressure to produce a lasting film. Furthermore, the existence of similar deposits on the internals of high-pressure boilers, operating at 1300 psig and 400 ppm concentration, can be taken to indicate that foam bubbles had burst at these points, and the discrepancy between the concentrations necessary to produce foam must have been due, at least in part, to the pressure, as the chemicals employed in each case were the same but without suspended matter in the test boiler.

5. A large high-pressure boiler produced carryover when the concentration reached about 600 ppm, this limit being slightly decreased with increase in steam output. However, when a $2^1/_2$ mesh screen was installed before the washer no carryover occurred at concentrations of 1000 ppm. The limit of concentration was not determined as the operators did not permit it to exceed 1000 ppm. The higher boiler water concentrations were possible in this case because the screen, washed by boiler water, diluted the foam bubble films and caused them to burst.

6. In another installation the employment of screens removed the restriction on maximum rating with normal high concentrations and permitted full design maximum production. Here violent mixing of the foam bubbles with boiler water ahead of the screens weakened the films by reduction in concentration.

7. In a number of instances boilers filled with water of known dissolved solids content have, when operated at moderate or high rates of steam output, shown a pronounced decrease of dissolved material. This material reappears when the rating is reduced. The inference is that it concentrated in bubble films that collected in parts of the boiler not accessible to the sampling device.

Misleading Indications

Although not bearing directly on the foregoing, experience in making such studies indicates that certain conditions may produce misleading indications. For instance, if leaks, even small ones, exist in the baffling separating the riser mixture from the steam space, local carryover conditions may indicate limitations on the boiler water concentrations, the rating or the water level that would be quite different if the leaks were corrected. Leaks have been found due to skip welding and to the disintegration of asbestos gaskets during acid washing.

Also, if the separating equipment comprising the drum internals produces a pressure drop it will reduce the circulating ratio. If such equipment is drained by pipes or into a separate chamber of the drum, it is essential that high pressure drops be avoided so that boiler water will not be drawn up through the drains and discharged with the steam. Coarse screens separated by corrugated fly screens have been indicated to have sufficiently high pressure drops to prevent drainage.

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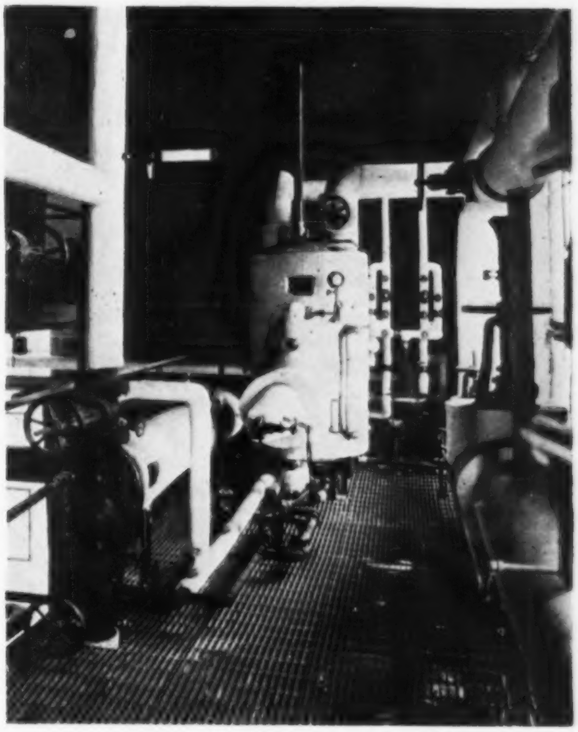
Heat Recovery with Continuous Blowoff

By M. C. McKEOWN

Cochrane Corp., Philadelphia

Calculations are made to demonstrate the procedure for determining the heat recovery and savings, under assumed conditions, with a system employing flash steam regeneration. A chart is also included, the use of which eliminates such calculations.



In this typical installation blowoff water is flashed into lower pressure steam in the flash tank, center. Remaining blowoff water passes through the heat-exchanger, at left, in which heat is transferred to incoming feedwater

THE primary purpose of a continuous blowoff system is to recover heat which would ordinarily be lost when boilers are blown directly to the sewer. In a system employing the "flash" principle, heat is recovered in two stages:

1. By the utilization of steam flashed from the blowoff.
2. By directing the hot waste water remaining after flashing, through a heat-exchanger.

Advantages of continuous blowoff can be economically attained through employment of the "flash" principle. With this method of operation, the concentrated boiler water is introduced into a tank operating at any desired pressure, although usually this pressure corresponds to that of the operating pressure of the feedwater heater in the simplest single-stage system.

Because the blowoff water is at a temperature corresponding to the pressure at which the boilers are operating, a reduction in the pressure causes "flashing" and steam is generated at the lower pressure. This steam can be utilized to heat feedwater in an open or deaerating heater or can be condensed in a closed heater or flash condenser, imparting heat to the water at a point beyond the deaerating heater. The unflashed water is generally passed through a heat-exchanger, the cooling medium being the makeup water.

The installation of a continuous blowoff system recovers practically all of the heat in the blowoff the only heat wasted being that which corresponds to the thermal difference between the incoming cooling water and the blowoff water going to the sewer.

The amount of blowoff required is, in most instances, determined by the permissible concentration of total solids in the boiler water. The accompanying table of general limits in the permissible concentration of boiler water is recommended by the American Boiler Manufacturers Association and Affiliated Industries.

Boiler Pressure, Psi.	Total Solids, Ppm.
0–300	3500
301–450	3000
451–600	2500
601–750	2000
751–900	1500
901–1000	1250
1001–1500	1000

In order to demonstrate the procedure used in determining heat recovery and savings, the following conditions will be assumed:

1. One boiler operating at 250 psig with an evaporation rate of 15,000 lb per hr.
2. Makeup water (100 per cent) containing 171 ppm or 10 gr per gal total solids.
3. Temperature of makeup 60 F.
4. Pressure of flash tank operation 5 psig.

Heat Recovery

Step 1—Calculate per cent blowoff required:

The boiler pressure is 250 psig, therefore, the maximum allowable concentration of total solids is 3500 ppm (approximately 200 gr per gal). Hence for every 20 gal of water delivered to the boiler, one gallon of concentrated water should be removed.

$$\frac{\text{Total dissolved solids in feedwater}}{\text{Permissible total solids in boiler}} \times \%\ \text{makeup} = \text{blowoff}$$

$$\frac{10}{200} \times 100 = 5 \text{ per cent blowoff.}$$

Step 2—Calculate the quantity of feedwater per hour:

Since evaporation is carried at a rate of 15,000 lb per hr. and the blowoff rate has been calculated as 5 per cent of the feedwater, the quantity of feedwater is determined as follows:

$$\frac{\text{Evaporation, lb per hr}}{\text{Evaporation (in per cent of feedwater)}} = \text{feedwater required.}$$

In this case, since the blowoff rate is 5 per cent of the feedwater, that remaining for evaporation will be 95 per cent of the feedwater, thus:

15,000/0.95	=	15,800 lb per hr feedwater
Feedwater, 100 per cent	=	15,000 lb per hr
Evaporation, 95 per cent	=	15,800 lb per hr
Blowoff, 5 per cent	=	800 lb per hr

Step 3—Calculate percentage of steam flashed from blowoff:

$$\frac{\text{Heat of liquid at boiler pressure} - \text{Heat of liquid at flash pressure}}{\text{Latent heat of steam at flash pressure}} \times 100 \text{ per cent} = \text{per cent steam flashed}$$

Using steam tables to obtain the values for Btu and latent heat:

$$\frac{381.6 - 196.1}{959.9} \times 100 = 19.4 \text{ per cent steam flashed}$$

19.4 per cent of 800 lb per hr blowoff = 155 lb per hr steam flashed

800 lb per hr blowoff − 155 lb per hr steam = 645 lb per hr water to heat-exchanger.

The steam (155 lb per hr) leaves the flash tank and enters the exhaust main.

The water (645 lb per hr at 227 F) is drained from the flash tank and directed through a heat-exchanger.

Step 4—Calculate amount of cooling water through heat-exchanger:

In heating makeup water to the temperature of the feedwater heater, approximately 15 per cent of the exhaust steam will be condensed. The cold makeup will, therefore, be 13,400 lb per hr to which is added sufficient condensed steam during the heating process, so that the boiler feed totals the required 15,800 lb per hr.

Step 5—Calculate the temperature rise on the cooling-water side of the heat-exchanger:

Assume the terminal difference of 15 deg F. This means that the blowoff water will go to the sewer at 75 F (15 deg higher than the incoming cooling water).

$$\frac{\text{Blowoff (lb per hr)} \times \text{temperature drop}}{\text{Cooling water (lb per hr)}} = \text{Temperature rise}$$

$$\frac{645 \times (227 - 75)}{13{,}400} = 7.3 \text{ deg F.}$$

Step 6—Savings:

The Btu saving is equal to the total heat in the boiler water in excess of the heat content of the cooling water available, if there were no terminal differ-

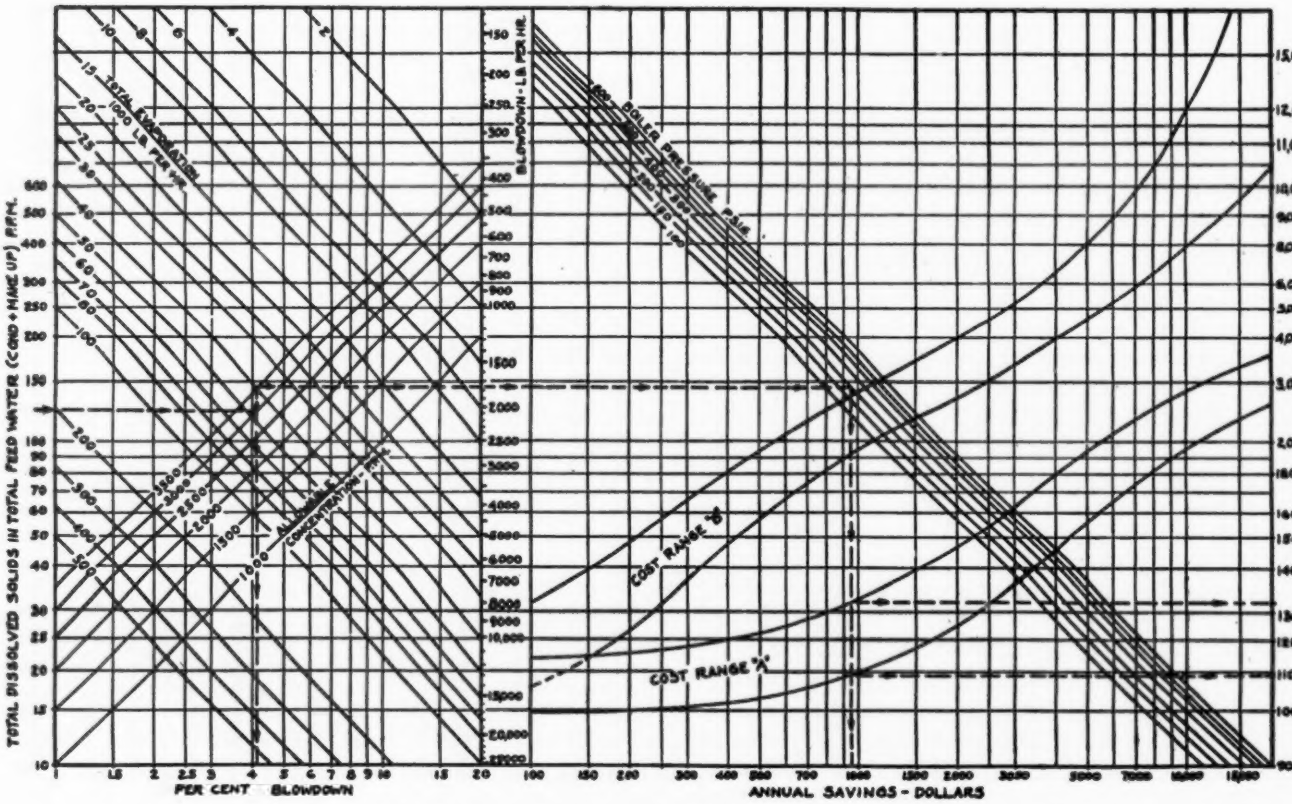


Chart for estimating savings and cost of continuous blowoff equipment

ence in the heat-exchanger. However, the terminal difference does represent a waste of heat and must be taken into consideration.

Blowoff (lb per hr) × (heat in liquid at boiler pressure − heat in liquid of incoming makeup) − (hot blowoff water to heat exchanger, lb per hr × terminal difference of heat exchanger) = Btu per hr saved. Substituting:

$$800\,(381.6 - 28) - (645 \times 15) = 273{,}205 \text{ Btu per hr saved.}$$

The actual dollar savings per year may be calculated from the following equation:

$$\frac{\text{Btu per hr saved} \times \text{hour of operation per year} \times \text{coal cost per ton}}{\text{Btu per lb coal} \times 2000 \times \text{boiler efficiency}} = \text{dollars saved.}$$

Chart for Saving Estimates

The foregoing information has been charted to eliminate the necessary calculations and provide an accurate estimate of cost for the equipment and the expected dollar savings. Following are directions for use of the accompanying chart:

The left-hand abscissa is the value of total dissolved solids (TDS) in the feedwater to the boiler including makeup and all condensate returns. Its actual value is found by multiplying the TDS in the raw makeup by the per cent of makeup.

Example:

TDS = 125 ppm
Allowable boiler concentration = 3000 ppm
Boiler pressure = 200 psi
Total evaporation = 40,000 lb per hr

Enter chart at the left at 125 ppm. and draw horizontal line to the 3000 ppm "Allowable Concentration" line. Through this point draw a vertical line to the bottom of the chart and read the per cent of blowoff (4.2 per cent). Now extend the vertical line, (if necessary) until it intersects the proper "Total Evaporation" line (40,000 lb per hr) and draw a horizontal line to the right from this point of intersection to the proper "boiler pressure" (200 psi), reading the total blowoff (1754 lb per hr) where the line intersects the blowdown column. From the intersection of this line with the proper boiler pressure line, drop a vertical line to the bottom of the chart and read the approximate "Annual Savings" ($950.00) for operation 24 hr per day, 300 days per year with 75 per cent boiler efficiency and 14,000-Btu per lb coal at $5.00 per ton on the grates. (For values other than these multiply the annual savings by the appropriate factor, as for instance for 12 hr operation multiply the annual savings by one-half.) Where this last line intersects the limits of Cost Range "A" draw two horizontal lines to the right-hand edge of the chart and read the approximate cost of equipment ($1090 to $1320) for a one-flash tank system. For total evaporations in excess of those covered by the chart, divide the total evaporation by ten and proceed as before, multiplying the determined blowoff and annual savings values by 10 for the final result. When this procedure is followed, Cost Range "B" is to be used directly without multiplying any factor.

Coal Problem in Italy

The problem of finding enough coal for Italy is the nightmare of any Italian statesman who is entrusted with the task of looking after his country's supply of raw materials. The fact is that Italy has hardly any coal mines worth mentioning and has to import a considerable quantity of coal in order to keep her industries going. This problem is so vital that it could not be left to private initiative and a special Board under the Ministry of Industry and the Ministry of the Treasury had to be created to control the importation and the allotment of coal.

A careful study has shown that Italy must import at least 600,000 tons of coal monthly to cover her absolutely essential needs. If, however, we take reconstruction into consideration, then 900,000 tons are necessary.

These figures do not look very impressive on paper but it is quite a different story when it comes to finding money with which to pay for these imports. What is more, it is not sufficient to find the money to guarantee the steady arrival of supplies and the recent strike of American miners has demonstrated this fact very painfully. In December only 344,325 tons of coal reached Italy. The American share in this figure accounts for 238,776 tons while Ruhr supplied 57,641 tons, South Africa 24,307 and Poland nearly 14,100 tons. When the American miners struck, Italy had to fall back on her slender reserves and especially on those prepared by her railways. Train schedules were reduced drastically and the railway stocks were greatly depleted.

The situation was helped somewhat by the fact that some straggler boats continued to arrive also after the declaration of the strike but it began to become really acute in January and remained so until the middle of the month when the first of the renewed shipments began to arrive. Naturally, these first arrivals cannot ease the situation very much as it is imperative to renew the depleted reserve stocks. Also, there is the undeniable fact that the shipping difficulties still persist and that the expected imports cannot be relied upon.

Thus, fearing that the arrivals will not come up to expectations the distributing offices are very careful with allotments and their program for January contemplates assigning only 320,000 tons to industry and 130,000 tons to railways even if imports totalling 598,000 tons are expected during this month.

The United States remains the chief source of supply with a monthly program of 400,000 tons, while 70,000 tons are expected from Germany, 60,000 tons from Poland, 45,000 tons from Belgium and 23,000 tons from South Africa.

It is clear from the foregoing that even if the most optimistic expectations are realized, Italy will receive during January just barely enough coal for her most essential needs, and quite inadequate for her reconstruction program. This means a check to the rebirth of Italian industry with resulting increase in unemployment and extra internal complications.

Rome, Jan. 12, 1947

ING. DOTT GIOVANNI COPPA ZUCCARI

[According to a statement issued by the Solid Fuels Administration on January 22 directions had been issued, under the Treasury Department's export program, for shipment to Italy during the month of January 501,500 tons of bituminous coal through UNRRA. This is exclusive of 25,500 tons shipped directly to the U. S. Army in Italy—EDITOR]

Television Enters the Power Plant Field

The first successful use of television in power plant work appears to be an installation that has been in practical operation for the past nine months at Hell Gate Station in New York City, where it is employed to observe boiler water level from the remote control room.

The instrument designated as the "Utiliscope", developed by the Farnsworth Television & Radio Corporation, in collaboration with Diamond Power Specialty Corporation, shows on a screen a picture of something currently taking place at a remote or inaccessible location. At Hell Gate the control room not only is some 325 ft distant from the boiler water-level gage but a building wall and a height equivalent to eight floors separates them.

This televised picture is produced by a photo-electric camera focused on the water-level gage and transmits sixty individual image fields a second. The picture is continuous with no measurable time lag between its transmission and reception.

Other Suggested Applications

It has been suggested that the Utiliscope might well be used to observe such additional operations in a power plant as coal feed to pulverizers or stokers, the presence of smoke from stacks, readings of meters at remote points, etc. Also, it is expected to be valuable in the observation of dangerous research experiments from a safe distance, particularly processes involving radioactive substances, as are certain to be encountered in atomic power plants.

The instrument takes 245 watts and is designed for operation at 60 cycles, 110 volts, single phase; although it could be supplied for other voltages and cycles if desired.

Progress in Synthetic Fuels

The annual report of Secretary of the Interior, J. A. Krug, released on February 4, states that crude petroleum output in 1946 was a record high of 1,731,000,000 bbl, which was 1.2 per cent greater than that in 1945. However, domestic production from known fields cannot be increased substantially without irretrievable loss, for oil is now being withdrawn at or near the maximum efficient flow of the wells. For several years past, discoveries of oil in new fields have not kept pace with the consumption, despite vastly increased exploration, and discovery costs have risen sharply.

Reductions in Cost Indicated

Reviewing 1946 research and development progress by the Bureau of Mines in the field of synthetic fuels, a program undertaken at the direction of Congress, the Secretary reported a number of outstanding achievements. Briefly, these were in part as follows:

At Pittsburgh and Bruceton, Pa., where Bureau laboratories are investigating the hydrogenation and gas synthesis methods of converting coal to oil, improvements in processes suggest material reductions in the costs compared with those in European countries.

In the hydrogenation process, lower pressures and lighter equipment have been found among the keys to production economy. The Bureau's laboratory and small pilot-plant studies have shown that coal can be converted into a distillable oil at relatively low pressures by employing special solvents and very active catalysts. Another radical departure from European practice is the Bureau's discovery that coal may be hydrogenated in a dry or powder state, thus simplifying the process by eliminating complicated and costly steps.

At Louisiana, Mo., a demonstration plant will be erected to produce 200 bbl of oil or gasoline daily from coal; and at Morgantown, W. Va., a laboratory has been established to develop cheaper methods of making carbon monoxide and hydrogen, as required in the production of synthetic fuel.

Underground gasification will also be fully investigated. In fact, the Bureau has a cooperative agreement with the Alabama Power Company covering an underground gasification experiment already under way at one of the latter's mines.

Oil Shale Studies

At Laramie, Wyo., the oil shale research laboratory has already obtained much of the fundamental information needed for the design and construction of shale oil pilot and demonstration plants. An oil shale demonstration plant is approaching completion at Rifle, Colo.

The report points out further that core drillings have disclosed that oil shale deposits in western Colorado contain more oil than had been estimated, averaging some 300 million barrels of oil per square mile or a total of about 15 billion barrels on Naval Oil Shale Reserve No. 1, alone. This is equivalent to about three-fourths of the proved petroleum reserve in the United States.

Present estimates, in the light of recent developments, now place the cost of producing gasoline from coal or oil shale at $7^1/_2$ to $9^1/_2$ cents per gallon, which is only a few cents higher than the current cost of gasoline from petroleum, exclusive of profit and interest on investment. However, Secretary Krug warns that the replacement by synthetic processes of any large segment of production from natural crude will require many years of conversion and construction; hence, the work prerequisite to such replacement must not wait until a crisis is imminent.

Camera focused on boiler water-level gage

Utiliscope viewer on instrument panel

Plans for Midwest Power Conference Taking Form

A TENTATIVE program has been announced for the Ninth Annual Midwest Power Conference to be held March 31 through April 2 at the Palmer House, Chicago. There will be seventeen technical sessions for the presentation of papers on steam power, diesel power, hydro power, system loads and other central station matters, fuels and combustion, air conditioning, heating, and electronics as related to power. In addition several luncheon meetings are scheduled.

"Power Supply for Fluctuating Loads" will be discussed by **H. E. Smith** of Commonwealth Edison Company and **C. W. Wright** of Delco Products Corporation, whereas **O. A. Hill, Jr.,** of the Public Service Company of Northern Illinois, and **G. L. Jorgensen,** of Commonwealth Edison Company, will present a paper on "Power System Loads."

There will be a session on feedwater treatment at which **L. B. Porter** of Illinois Water Treatment Company and **A. E. Kittredge,** of Cochrane Corporation, will present papers. At another session, on metallurgy of power plants, **J. J. Kanter,** of Crane Company, and **Hugh Ross,** of Allis-Chalmers will have papers.

"Energy Sources of Tomorrow" and "Methods of Firing Pulverized Coal" will be the topics under Fuels and Combustion. **R. A. Sherman,** of Battelle Memorial Institute, will discuss the former and **Otto de Lorenzi,** of Combustion Engineering Company, will discuss the latter.

Small power plants as used in the paper industry will be the subject of a talk by **Robert Krause** of the Container Corporation of America, and **Parker A. Moe** will discuss the problems of air pollution from small boiler plants.

At the session on diesel power, **A. G. Hoppe,** of the Chicago, Milwaukee, St. Paul and Pacific Railway, will report on "The Performance of the Diesel Locomotive," and **C. G. A. Rosen,** of Caterpillar Tractor Company, will present a paper on "Diesel Developments of Significance."

Two sessions will be devoted to hydro power. At one of these **E. R. de Luccia,** of the Federal Power Commission, will relate progress on the "Coordination of Hydro and Steam Power in the Missouri Basin." Other speakers on hydro will be **P. L. Mercer** of the Union Electric Power Company and **Vincent Thieman** of the Wisconsin Public Service Corporation.

The A.S.M.E. is sponsoring the luncheon on the opening day of the Conference as well as the afternoon session on "Central Station Practice." **C. H. Smoot,** of Republic Flow Meters Company, will discuss control problems and **W. D. Halsey,** of the Hartford Steam Boiler Inspection and Insurance Company will present safety aspects within the power plant.

The luncheon on the second day, as well as one session that afternoon, will be sponsored by the A.I.E.E. Subjects and authors will be "Aerial Cables for Electric Distribution," by **G. H. Landis,** of Central Hudson Gas and Electric Corporation, and "Corrosion of Underground Cable Sheaths Due to Local Cells," by **L. F. Greve,** of Commonwealth Edison Company.

The Western Society of Engineers, which has long cooperated with these conferences, will sponsor the General Session on "Civic Duties of the Engineer" which is scheduled for the afternoon of April 2. Among the speakers will be **Mayor E. J. Kelly** of Chicago, **R. M. Gates,** president of Air Preheater Corporation and past president of the A.S.M.E., and **Joseph Lohman** of the University of Chicago.

"Electronics in Industry" will be dealt with in two sessions which will take up such application as heating in the wood industry, control, power and process instrumentation, power line corner-current equipment, etc.

The "All Engineers Dinner" to be held on the evening of April 1 will have as the principal speaker **R. D. Deupree,** president of Procter & Gamble and former executive chairman of the Army and Navy Munitions Board.

Dean Stanton E. Winston, Illinois Institute of Technology, will direct the Conference for the eighth time and will be assisted by **E. A. Whitehead,** research professor at that Institute who is the newly appointed secretary.

Unfired Pressure Vessel Code Redrafted

The Boiler Code Committee of The American Society of Mechanical Engineers announces that its special committee to revise Section VIII of the A.S.M.E. Boiler Construction Code (Unfired Pressure Vessel Code) has just completed its work and has submitted a report dated January 1947.

One of the outstanding features of the new draft is the development of a more logical arrangement of material, which closely follows that in the A.P.I.-A.S.M.E. Unfired Pressure Vessel Code. The basic minimum requirements are essentially those established in the alternate rules for unfired pressure vessels, issued as a part of the 1944 addenda to the Code. Besides improved arrangement, the proposed revision embodies the following additional features: (1) Improved and extended rules for the design of formed heads under internal and external pressure; (2) provision for the design of cylindrical shells under external pressure at elevated temperature; (3) joint efficiency for fusion-welded vessels established on a premium basis; (4) spot examination of fusion-welded vessels as a minimum requirement; (5) incorporation of a non-mandatory

appendix as a guide for the inspection of vessels in service.

The Boiler Code Committee invites all interested persons to review the proposed revision and to submit comments thereon to the committee. The new draft is obtainable from the secretary of the Committee at A.S.M.E. Headquarters, 29 West 39th Street, New York 18, N. Y., at $1 per copy

The committee plans to hold several public hearings on the proposed revision before final consideration for adoption. The first hearing has been tentatively scheduled for Houston, Tex., on May 1, to be followed by another in Los Angeles, Calif., on May 7.

It should be noted that the proposed revision in no way affects the forthcoming issuance of the 1946 edition of the Unfired Pressure Vessel Code. There is no indication at present as to the date of final adoption of the proposed revision.

Work to Start on Atomic Laboratory

Construction of the Knolls Atomic Power Laboratory to be built near Schenectady, N. Y., by the Atomic Energy Commission will start this spring, it has been announced by L. E. Johnston, Area Engineer for the Commission. The laboratory is being erected under the supervision of the General Electric Company, which will operate it for the government when completed. Mr. Johnston said that scientists and engineers will probably begin to occupy the new building by the middle of 1948.

The new atomic laboratory is to be located on part of a 386-acre tract in nearby Niskayuna. On another part of the property the new General Electric research laboratory is now rising. The two laboratories, whose work will closely mesh, are to be operated as a unit under the direction of Dr. C. G. Suits.

A number of scientists for the project have already been recruited, said Dr. Suits, and are at work in the present G-E laboratory buildings. More are being employed as rapidly as qualified men and women can be found. Physicists, metallurgists, chemists and chemical engineers—technical men of all kinds—are needed, he declared.

A number of buildings will form the Knolls Atomic Power Laboratory. In one will be located an experimental pile. Such a pile, it is expected, will form the firebox and boiler of future atomic power plants. Other buildings of the group will be devoted to offices, metallurgy, chemical engineering and chemistry. Another building will house a 3,500,000-volt electrostatic, or Van de Graaff, generator for atom-smashing studies.

An earlier government announcement about the new laboratory said that its purpose would be to conduct research in all phases of atomic power development, and that in addition research on specific problems in connection with the operation of the Hanford Engineer Works in the state of Washington, now operated by General Electric's Chemical Department, would be carried on in the new facility.

Architect's sketch of Knolls Atomic Laboratory

A.S.M.E. Spring Meeting

The 1947 Spring Meeting of The American Society of Mechanical Engineers will be held in Tulsa, Okla., March 2 to 5, with headquarters at the Mayo Hotel. The general theme of the meeting will be "The Industrial Growth of the Southwest." There will be some twenty technical papers at twelve sessions including several on petroleum, gas and diesel engines, the gas turbine, the heat pump, and a talk by **W. T. Reid** on "The Fuel Industry in Japan." Mr. Reid has recently returned from an extended stay in Japan where he made a study of the fuel situation for the Bureau of Mines.

REVIEW OF NEW BOOKS

Any of the books here reviewed may be secured through Combustion Publishing Company, Inc., 200 Madison Ave., N. Y.

Steam Power Stations, Third Edition, 1946

By Gustaf A. Gaffert, Sc.D.

The first edition of this book appeared in 1937 and the second in 1940. The present edition brings the reader up to date on the latest developments in the steam plant field. The author, now mechanical engineer and partner of Sargent & Lundy, Chicago, has a background of several years of teaching experience in courses in heat-power engineering followed by several years in the field of mechanical design of steam power stations.

The text is a concise and practical book on steam power stations which is confined to the mechanical engineering features. It deals with the construction, performance characteristics and integration of the major and minor items of plant equipment. The introduction includes a historical background of the utilization of power and the growth of the power industry. Successive chapters dealing with the various equipment items begin with a discussion of fundamentals followed by descriptions of various modern types together with performance characteristic calculations and end with a "problems" section.

It is the aim of this book to make the approach to the subject comprehensible to engineering college students. Chapters I to XVII dealing with equipment and steam machinery characteristics can be readily covered in one semester. Chapters XVIII to XXIV would serve as a text and reference for a subsequent course in design in which economy and integration of machinery are considered.

The text is profusely illustrated with diagrams and cuts of modern types of equipment and many graphs and charts are included. The numerous typical computations should be of value in grasping the problems of plant design. These include heater-extraction-cycle computations, combustion calculations and boiler heat balance, circulation, heat transfer in economizers and air heaters and high-pressure extraction-cycle computations

The chapter on feedwater includes the four objectives of feedwater treatment and discusses various methods of treatment such as lime-soda, phosphate, sodium zeolite and hydrogen-zeolite. That on fuel-burning equipment covers stokers, pulverized-coal systems, oil and gas firing and combustion control systems.

"Cycle Arrangements" is the title of Chapter XXI and includes discussions of reheating and regeneration and of cycles for recent stations.

The following chapter titles give an idea of the complete coverage of the subject: Steam Engines, Steam Turbines, Condensers, Feedwater Heaters and Evaporators, Feedwater Treatment, Fuels and Combustion, Steam Generating Units, High-Pressure and Binary-Cycle Boilers, Dust Collectors, Economizers and Air Heaters, Superheaters and Reheaters, Fuel-Burning Equipment, Duct Work and Piping, Draft Systems, Coal and Ash Handling, Pumping Equipment, Steam Station Costs, Load Curves and Plan Location, Selection of Prime Movers and Steam Generating Equipment, Cycle Arrangement, Binary Vapor Cycles, Optimum Cycle and Units and Station Design.

The book contains 613 pages, 6 × 9 in., is cloth-bound and priced at $5.50.

Applied Atomic Power

This book is written with the object of informing the layman in relatively simple language, that can be understood by careful reading, what atomic power is. It traces in an elementary way the development of atomic energy from early work in radioactivity to its present-day scientific status and reviews the possibilities, in so far as we now know them, of the application of atomic power to industrial progress.

The authors, all outstanding men in the fields of science and engineering, are: Edward S. C. Smith, Professor of Geology, Union College; A. H. Fox, Assoc. Professor of Mathematics, Union College; R. Tom Sawyer, American Locomotive Company; and H. R. Austin, Executive Vice President, The Kellex Corporation.

The various terms, such as isotopes, transmutation, fission, chain reactions, moderator and pile, frequently referred to in connection with the subject of atomic or nuclear energy are defined and explained. The physical background of atomic energy production with the basic introduction to nuclear reactions, nuclear fission and chain reactions in the earlier part of the book prepares the reader for the summary of the development of atomic energy leading to the atomic bomb which follows.

This next section (Part III) was abstracted by Dr. Fox from the Smyth Report. It gives a summary of the progress at various stages throughout the war period and includes an explanation of the separation of the uranium isotopes by various methods. There is a complete chapter on plutonium production as accomplished at both the Clinton and Hanford plants.

Part IV covers some possible methods of converting atomic energy into mechanical power. Included are applications of power from the uranium pile to boilers and steam, mercury or gas turbines; power direct from uranium or plutonium employing an atomic powered combustion chamber in an open- or closed-cycle, gas-turbine plant and also atomic-powered jet-propulsion units for rockets or planes; construction of an atomic-powered 35,000-hp gas turbine plant; and construction of atomic-powered locomotives, as well as some marine possibilities.

The last part of the book enumerates some of the benefits which industry might expect from the engineering principles, new and improved equipment and new methods that have been developed as a necessary prerequisite of the atomic bomb.

The appendices include a résumé of the work on the atomic bomb, a conversion table for energy units and a table of nuclear and atomic masses of isotopes.

This book should serve as a guide to the thinking of all who wish to see the benefits of atomic power applied to constructive endeavors.

The book is 6 × 9 in., contains 227 pages and may be purchased for $4.00.

Thermodynamics

By G. A. Hawkins

Drawing on his broad background in teaching at Purdue University as well as in the practical application of thermodynamics in engineering, Professor Hawkins has turned out an excellent text. Emphasis has been placed on those concepts and applications that his experience undoubtedly has shown to be of most value to the engineer in the practice of his profession.

By adopting the current usage of solved problems to illustrate the points under discussion, clarity is imparted to both students and to engineers renewing their familiarity with the subject. This value of the book is further enhanced by a comprehensive and well-arranged index and by the inclusion of the fundamentals of heat transmission.

The breadth of coverage of the field is indicated by the chapters: 1. Fundamental Concepts; 2. The First Law of Thermodynamics; 3. Solids, Liquids and Gases; 4. The Ideal or Perfect Gas; 5. Equations of State for Real Gases; 6. Specific Heat of Gases; 7. The Use of Tables for Computing the Properties of Vapors; 8. Frictionless Non-Flow Ideal Gas and Vapor Changes; 9. The Carnot Cycle and the Second Law of Thermodynamics; 10. Available, Unavailable Energy, and Entropy; 11. Entropy Changes for Ideal Gases and Vapors; 12. Mixtures of Ideal Gases and Vapors; 13 Combustion; 14. The Flow of Gases and Vapors Through Nozzles and Orifices; 15. Ideal Cycles of Internal Combustion Engines; 16. Air Compressors and Air Engines. 17. The Gas Turbine and Jet Propulsion; 18. Vapor Cycles; 19. Mechanical Refrigeration; 20. General Thermodynamic Equations; 21. Introduction to Heat Transfer.

The book contains 436 pages, $8^1/_2 \times 5^3/_4$ in. and is priced at $4.50.

Specification for Steel Piping Materials

In addition to all A.S.T.M. specifications covering steel piping and tubing the December 1946 compilation of A.S.T.M. Specifications for Steel Piping Materials includes requirements on a number of

other materials which are used in piping installations, such as castings, forgings, bolting materials and nuts.

The book includes 14 specifications covering various types of pipe ranging from ordinary carbon pipe for a variety of uses to high-alloyed steels for high-temperature and high-pressure service. Thirteen specifications cover various types of boiler, superheater and miscellaneous tubes including four standards on stainless tubing. Three specifications cover still tubes and a similar number pertain to heat-exchanger and condenser tubes. Five standards cover castings used in pipe installations including valves, flanges and fittings and there are four specifications covering forgings and welding fittings. Three standards cover carbon and alloy-steel bolting. Also, the book is made more complete by the addition of E19-46 concerning austenite grain size in steels.

In paper cover, this 307-page publication is priced at $3.00.

NEW CATALOGS AND BULLETINS

Any of these publications will be sent on request

Degasification of Water

Publication No. 4076, issued by the Cochrane Corporation, points out briefly some of the problems in the degasification of water and indicates generally the equipment used in the solutions of these problems. Described in the bulletin are the processes for the removal of oxygen and carbon dioxide from cold water; for hydrogen sulphide, ammonia, oxygen and carbon dioxide removal from process water and feedwater; together with illustrations of the equipment used in these various processes. Also described is the atomizing type deaerator used for degasification of feedwater for marine boilers together with some test data showing typical performance of this type of equipment.

Electrofluid Drive

Electrofluid Drive is the subject of a 16-page catalog (No. 2085) recently published by Link Belt Company. This new and revolutionary type of "packaged" power transmission unit is a motorized hydraulic combination which possesses several advantages including easier starting with lower current demand, delivery of maximum torque to overcome a momentary demand, smoothing out of shock loads, cushioning of torsional vibration and extremely low maintenance. The unit is supplied with motor sizes up to 20 horsepower for such power plant uses as driving water screen intakes, conveyors, feeders, stokers, etc.

Furnace Enclosure

The Geo. P. Reintjes Company has issued Catalog C-46 describing their suspended furnace walls, air cooled and insulated walls, arches, drum end seals, water wall supports and backing, various shaped tiles and furnace accessories. Also described is the Reintjes non-fluxing veneer facing used to prevent slag from adhering to the wall surface. The catalog is well illustrated with typical installations, assembly views and construction details. The advantages of suspended versus solid walls are enumerated.

Pumps

The Milton Roy Company, Philadelphia, has issued Catalog No. 146 describing Milton Roy controlled volume, chemical and high-pressure pumps. These pumps are standard simplex and duplex types for pumping in controlled metered volume one pint to 2600 gallons per hour against pressures up to 20,000 lb per sq in. Particular applications include feedwater treating, the introduction of chemicals and automatic pH control. Also included are capacity selection tables and of particular interest are color charts showing twelve different materials of pump construction and recommendations for their use when handling a great variety of liquids.

The Quimby Pump Division of H. K. Porter Company, Inc., has issued Bulletin No. 300A on their Close-Coupled Centrifugal Pump. This pump, designated as Model "Q," is designed for general service with capacities from 10 to 1000 gpm. Type Q66 is a close coupled pump designed to cover the range beyond that of single-stage pumps and is built in sizes up to 275 gpm. Other Quimby pumps mentioned are screw pumps and streamflow rotex pumps.

Smoke Prevention

A booklet entitled "Smoke—Its Cause, Cost and Prevention" has been released by the Perfex Corporation, manufacturer of automatic temperature controls and instruments. Included are descriptions of the various types of coal and oil firing, the causes of smoke, corrective measures and means of assuring smoke-free control.

Temperature Regulators

Bulletin 454 issued by the Leslie Company is a 24-page booklet covering engineering, operating and maintenance data on temperature regulators and controllers. Colored illustrations show the construction details of each type of regulator or controller. Also included are sizing and capacity tables useful in the selection of this equipment for specific applications. A section is devoted to instructions for installing, operating, dismantling, cleaning, and assembling.

Water Softeners

The Liquid Conditioning Corporation has issued Bulletin 4 which describes five types of Liquon Hot Process Lime-Soda Softeners which cover a wide range of requirements. Flow diagrams of each type are shown. The bulletin also includes a description of Liquon hot process phosphate treatment.

Pure Titanium

The U. S. Bureau of Mines has developed a process for the production of ductile titanium that can be fabricated and worked as are other more common metals. This process, which is employed at the Bureau's Intermountain Experiment Station in Salt Lake City, involves the reduction of titanium tetrachloride with pure molten magnesium in the presence of helium under slight pressure.

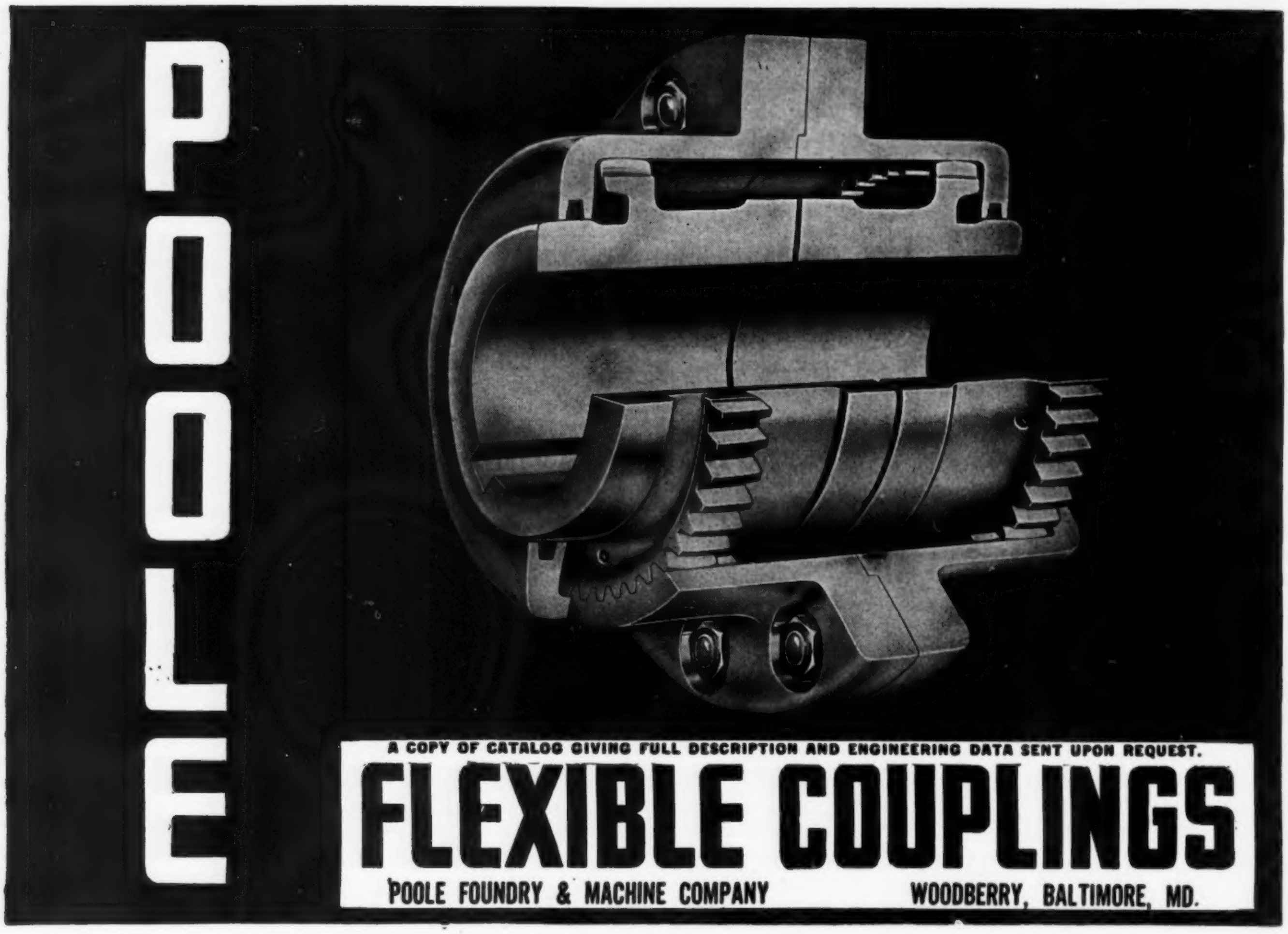
Ranking ninth in abundance among the elements, titanium ranks fourth among the metallic elements suitable for engineering purposes, being exceeded only by iron, aluminum and magnesium. It is about twice as heavy as magnesium and has a high proportional limit. Bureau metallurgists have determined this to be as high as 75,000 lb per sq in. for cold-worked pure titanium as compared with about 25,000 lb for stainless steel. It is corrosion-resistant, can be surface hardened, and combines the properties of stainless steel with those of strong aluminum alloys. However, it is still relatively expensive to produce.

Titanium and its compounds are obtained chiefly from ilmenite and rutile which before the war were imported from India, Australia, Brazil, Norway and Portugal, but which is now produced domestically from deposits in the Adirondack region of New York, as well as in Virginia, North Carolina, Florida, Arkansas and Wyoming.

Power Shortage in Pacific Northwest

In view of the present power shortage in sections of Washington, Oregon, Idaho, Utah and Western Montana, the Federal Power Commission on January 17 granted the Puget Sound Power & Light Company permission to resume certain wartime interconnections without affecting its jurisdictional status.

In issuing this order the Commission explained that the constantly increasing demand for electric energy in this region has resulted in a load exceeding that reached during the peak of war production. One of the factors aggravating the situation has been the return of two 75,000-kw units to the Shasta Project in Northern California which had been diverted temporarily during the war to the Grand Coulee power house.



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